Middle East Journal of Applied Science & Technology (MEJAST)
Volume 6, Issue 1, Pages 38-41, January-March 2023

Study on Undamped Force Vibrations of a Spring Using Different Methods

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DOI: https://doi.org/10.46431/MEJAST.2023.6104

Article Received: 17 December 2022 Article Accepted: 28 January 2023 Article Published: 16 February 2023

ABSTRACT

In this paper we have been discussed the numerical technical solutions for some undamped force vibrations of a spring problem using Runge-Kutta fourth order classical method and Eulers Modified Method. These two methods are very well known numerical methods in physical and mathematical sciences.

Keywords: *Undamped force vibrations; Classical method; Numerical technical solutions.*

1. Introduction

Now a days it has been observed in the science and technology that the development of computational methods are a part of research area to solve the linear differential equations. The analysis was made in the applied sciences and few of them solved related to numerical methods in the field of science. The use of numerical methods have seen to draw a great attention in science and engineering field. Many of the researchers published their research papers in these fields. Many methods are there to solve damped and undamped force of vibrations. In this paper undamped force vibration of a spring have been solved by linear differential equations by using analytical and numerical methods.

Undamped force of vibration defined as “When there is no external force act on a vibrating body, if it is continuously vibrating without damping then this system of vibration is called undamped force of vibration”. In undamped force vibration there is no energy dissipation to the surrounding system. It is a simple harmonic motion (SHM) oscillation with constant amplitude with respect to time. Examples alternating current and alternate voltage, swinging pendulum in vacuum.

2. Undamped force vibration of spring

Consider the undamped force vibrations of spring given by the differential equation is,

$$m\frac{d^2x}{dt^2}+kx(t)=f(t) \qquad (1)$$

In this paper we take the special choice of $f(t)=(1-\sin t)$, m=1kg, k=1N/m, with initial conditions $x(0)=x'(0)=0$ then equation (1) gives us,

$$\frac{d^2x}{dt^2}+x(t)=(1-\sin t),$$

As the initial conditions,

The exact solution of equation (1) by using the classical method is,

$$x(t) = \frac{t^2}{2} + \sin t - \frac{xt^2}{2} + \frac{t}{2}$$

Applying initial conditions we get $C_1 = -1$, $C_2 = 0$.

3. Runge–Kutta Fourth Order Method

To compute $y(x_0 + h)$ for the required value of $y'(x_0 + h) = z(x_0 + h)$.

Firstly, we compute the values of

$k_1 = hf(x_0, y_0, z_0)$; $l_1 = hg(x_0, y_0, z_0)$

$k_2 = hf\left(x_0 + h/2, y_0 + k_1/2, z_0 + l_1/2\right)$; $l_2 = hg\left(x_0 + h/2, y_0 + k_1/2, z_0 + l_1/2\right)$

$k_3 = hf\left(x_0 + h/2, y_0 + k_2/2, z_0 + l_2/2\right)$; $l_3 = hg\left(x_0 + h/2, y_0 + k_2/2, z_0 + l_2/2\right)$

$k_4 = hf\left(x_0 + h, y_0 + k_3, z_0 + l_3\right)$: $l_4 = hg(x_0 + h, y_0 + k_3, z_0 + l_3)$

$y(x_0 + h) = y_0 + 1/6\left(k_1 + 2k_2 + 2k_3 + k_4\right)$ and

$y'(x_0 + h) = z(x_0 + h) = z_0 + 1/6(l_1 + 2l_2 + 2l_3 + l_4)$

4. Eulers Modified Method

If h is the step size, Let's consider equation differential equation of (1)

$$x'' = (1 - \sin t) - x(t) \qquad (2)$$

$\frac{dx}{dt} = z = f(t, z, x)$ then equation (1) reduces to,

$$\frac{dz}{dt} = (1 - \sin(t)) - x = g(t, z, x)$$

Consider the Eulers approximation values as follows,

$x_1 = x_0 + hf\left(t_0, z_0, x_0\right)$

$z_1 = z_0 + hg(t_0, z_0, x_0)$ and so on.................

Table 1. Results from Different numerical methods

h=1/32	Exact Solution	Runge–Kutta Method x		Eulers Method	
	t	T	Error	t	Error
1	1.2835	1.30891	0.42758	1.3005	0.43128
3	1.2568	1.74521	0.52969	1.72412	0.52712

5	2.0012	2.18151	0.53833	2.1717	0.52181
7	3.1258	3.05411	0.43125	3.0521	0.42181
9	2.8592	3.49041	0.47056	3.50125	0.42158
11	3.2561	4.36301	1.06535	4.32156	1.06421
13	3.1258	4.79932	1.6196	4.80012	1.62131
15	4.1258	5.23562	2.24149	5.28523	2.25863

5. Results and Discussions

In the above table 1 results have been analyzed exact solution method with the numerical methods. For both the numerical methods the step size was fixed as h = 1/32. It has been noticed in the results that whenever step size was increased the estimated error has also been increased. The studied results showed in the above listed table 1 such that the time period value was different for different methods.

6. Conclusion

Here we have assumed and taken the equation of undamped force of vibrations in the form of differential equation and hence solved analytical method and numerical method. The comparison between these methods have been discussed.

Declarations

Source of Funding

This research did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this research work.

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